
ENVIRONMENTAL Fact Sheet



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Arsenic in Drinking Water

Arsenic is an important contaminant in New Hampshire's geology. Drinking water supplied from bedrock wells, also called drilled or artesian wells, and less frequently from dug wells, may contain arsenic at elevated amounts. The important question is, what is the concentration of arsenic?

Where Does Arsenic Come From?

Arsenic (chemical symbol As) occurs naturally in many parts of the United States, including New Hampshire and other areas of New England. In fact, arsenic was mined commercially in New Hampshire during the 1800s. Arsenic also occurs as a result of human activities. Activities that could have left arsenic residuals include, for example, apple orchard spraying and coal ash disposal. Most arsenic in New Hampshire wells is believed to be naturally occurring. Arsenic in water has no smell, taste or coloration when dissolved in water, even at high concentrations. Thus only water quality testing can determine its presence.

Health Effects

Arsenic has been classified by the U.S. Environmental Protection Agency (EPA) as a human carcinogen (cancer causing agent). Long term exposure to arsenic has been linked to cancer, cardiovascular disease, immunological disorders, diabetes and other medical issues. Specific health questions concerning arsenic should be directed to your personal physician. For general **health** information concerning arsenic call the DES Environmental Health Program at (603) 271-4608 or refer to the fact sheet at www.des.state.nh.us/factsheets/ehp/ard-ehp-1.htm. Where drinking water is rusty colored and has arsenic, the rusty particles may **concentrate** the arsenic. Thus do not consume rusty colored water.

How Much is too Much?

The standard that limits arsenic in public water supplies, called a maximum contaminant level (MCL), has been made more stringent in the last few years. The more stringent standard is 0.010 milligrams per liter (mg/L). This standard may also be expressed as 10 parts per billion (ppb).

Testing Your Well

The cost for an arsenic test is \$10 per sample at the DES Laboratory. DES recommends that at least two tests be processed before concluding the well's arsenic concentration. This recommendation is made since well water quality can change due to rainfall amounts, length of pumping time, seasonal change, etc.

Frequency of Arsenic Occurrence

Approximately 3 percent of New Hampshire wells exceed the concentration of 0.05 mg/L. Approximately 13 percent of New Hampshire wells exceed the revised and more stringent

drinking water standard of 0.010 mg/L. The statewide distribution of arsenic in drinking water wells is shown below.

<u>Concentration</u>	<u>Percent of all bedrock wells</u>
greater than 0.05 mg/L	3%
0.025-0.049 "	5%
0.010-0.024 "	5%
0.005-0.009 "	6%
less than 0.005"	80%

Reducing Arsenic in Your Water Supply

There are at least three approaches that one could take to reduce exposure to arsenic from drinking water: connect to a municipal water system, construct a new well, or install water treatment. Additional considerations for each option are discussed below.

Municipal Water

In most cases, municipal water is not available or is too costly to extend to all areas where arsenic concentrations are high. From the perspective of public health and real estate values, town water is preferable to one or more water treatment devices in the basement of a home. Where municipal water is a possibility, we suggest discussing the funding of a pipeline extension with your neighbors. A joint effort will reduce individual costs and provide an area-wide solution if arsenic or other contamination is extensive.

An important action before such discussions is to **test all wells** in the area for arsenic. Even if arsenic is not present, your neighbors may have other water quality problems, such as radon and other forms of radioactivity, fluoride, iron and manganese, hardness, and/or odor, which may influence their willingness to financially support a water main extension. See fact sheet www.des.state.nh.us/factsheets/ws/ws-6-7.htm for further information concerning the extension of a municipal water piping and fact sheet <http://www.des.nh.gov/factsheets/ws/ws-2-1.htm> concerning recommended water quality testing of private wells.

New Wells

A new dug well or point well installed in sand and gravel is much less likely to have a meaningful concentration of arsenic. Such a well typically requires a relatively shallow and stable water table. Unfortunately, in many areas of New Hampshire, the soil type and a year-round sustained water table are not favorable for shallow wells. Before drilling a new bedrock well, determine the water quality and arsenic levels of neighboring wells and evaluate alternate well type and locations. Other water quality concerns with bedrock wells include radioactivity and fluoride.

In-Home Treatment

Arsenic Types. Before discussing treatment, a few words are necessary about arsenic chemistry. There are typically two variations, or species, of arsenic in water: "arsenic III" and "arsenic V." The numbers III and V describe the valence of the arsenic in the molecule when the arsenic compound is dissolved in water. This dissolved form of an element or compound in water is called an "ion." The form of the arsenic, III or V, is very important relative to the effectiveness of many treatment methods. Arsenic V is generally much easier to remove from water than arsenic III.

Determining the species of arsenic is normally a component of the sample collection step. As such, it noticeably adds to the complexity and possible expense of collecting a water sample for analysis. Arsenic species testing is discussed below.

Arsenic Speciation Testing. Two samples are collected in the field and then processed in the laboratory. The first sample is tested for total arsenic. The second sample is passed through a fine mesh anion exchange resin. The resin will remove only arsenic V. Thus, the water passing through the anion resin contains only that arsenic in the valence III form. The difference between the total arsenic sample and the sample filtered by the anion resin, is the amount of arsenic V present in the water.

Arsenic Oxidation. If the well contains a significant level of arsenic III, DES recommends oxidation pretreatment. Common oxidants include liquid chlorine (bleach), hydrogen peroxide (H₂O₂), ozone, or passing the well water through a cartridge of manganese dioxide media. Since the ratio of arsenic species may not be constant through out the year, many equipment installers provide an oxidizer pretreatment rather than sampling for both species. Some wells may have varying amounts of arsenic III over the year.

Sizing of Treatment Devices: Whole House" Vs. "Point-of-Use"

In-home water treatment devices come in two sizes: very small (often called **under-the-sink** or **point-of-use**), and **whole house**, where all water used within the home is treated to remove arsenic. Point-of-use (POU) produces only a few gallons of treated drinking water per day. This treated water is typically available at a new supplemental faucet placed near the kitchen sink. When using this POU option, **drinking water and cooking water** should be obtained from the separate treated faucet located at the kitchen sink area. Household discipline is needed to ensure that most drinking water is taken from the treated water faucet, while water for dish washing can be obtained from the untreated faucet.

Skin Absorption

One concern with choosing point-of-use treatment is the level of arsenic absorption through the skin when the water is used for bathing. The DES Environmental Health Program has concluded that point-of-use treatment is adequate if the arsenic concentration of the water used for bathing, laundry, dishwashing, and other nonconsumptive uses is less than 0.500 mg/L (500 ppb). This assumes that inadvertent **consumption** of untreated water by infants, such as drinking bath water is kept to a minimum, particularly as arsenic concentrations rise.

If the arsenic concentration in water for these non-consumptive uses is over 0.500 mg/L (500 ppb), please call the DES Environmental Health Program at (603) 271-4608 to discuss skin absorption and other sources of arsenic in the diet, in more detail.

Types of Point-of-Use (POU) Treatment

POU treatment devices are generally the most cost effective method for treating arsenic in drinking water. A complete POU installation should have a water meter, pretreatment oxidizer, arsenic removal component, possible second arsenic removal component in series and an accumulation tank. The water meter would identify the volume of water consumed and can be used to project the expected longevity of treatment components. In addition, the lower cost of POU concept can allow for a series configuration of two arsenic devices to assure complete treatment. In a series configuration, the first unit does the heavy removal and the second provides backup and polishing. POU systems normally produce approximately two to five gallons of treated water per day.

Common POU treatment methods are available for point-of-use arsenic treatment; adsorptive media, reverse osmosis, anion exchange cartridge, and distillation.

1. Adsorptive Media

Many new adsorptive media have been introduced into the market place over the last five years

and packaged into various modular size cartridge products. These media have an affinity for a limited number of dissolved minerals including arsenic. Activated alumina used to reduce arsenic in the past is an adsorptive media. In this process well water passes through the media. The arsenic "sticks" to the surface of the media by adsorption, while the remaining water passes through the media device. Minerals from the media are not released into the water.

In addition to arsenic, some of these media remove other contaminants including fluoride and uranium. Fluoride, at appropriate concentration (1-2 mg/L), is beneficial in reducing tooth decay. See fact sheet <http://www.des.nh.gov/factsheets/ws/ws-3-5.htm> concerning fluoride and fact sheet <http://www.des.nh.gov/factsheets/ws/ws-3-11.htm> concerning mineral radionuclides.

Cost of Adsorptive Media. The estimated installed cost of a single cartridge treatment configuration, with pre-oxidation cartridge, is approximately \$600; a duplex media cartridge configuration costs approximately \$800. Replacement adsorptive media cartridges may cost in the range of \$50-\$200 depending on the media type and longevity. POU cartridges are typically sized for six months to one year before change-out.

Advantage/Disadvantages. Adsorptive media typically have the lowest first installation cost. Some adsorptive media will remove arsenic III without pretreatment however the longevity of the media for arsenic III is noticeably less than that for arsenic V. Adsorptive media can have higher flow rates than RO. Adsorptive media targets only those contaminants identified on the manufacture's label or brochures. When multiple health based contaminants are present, the one with the weakest affinity for the media will control the media replacement frequency. The release of low affinity contaminants is called "dumping" and should be evaluated when establishing a monitoring program to judge the effectiveness of overall treatment. Cartridge change-out should occur periodically based on the gallons processed and the results of performance samples.

2. Reverse Osmosis (RO)

In the RO option, untreated water, under pressure, flows past a special membrane. The membrane allows water molecules to migrate through while retarding the passage of arsenic and many other contaminants. The contaminants remain on the untreated side of the membrane and are disposed of into a dry well, septic system or sewer. Treated water accumulates on the other side of the membrane and is held in a small pressure storage tank until needed. See fact sheet <http://www.des.nh.gov/factsheets/ws/ws-2-11.htm> for more information concerning RO.

Cost of RO. A basic point-of-use RO device, with a pre-oxidation cartridge to address arsenic III, would cost approximately \$950-\$1,300. Annual maintenance consists of replacement of the pre-treatment sediment cartridge every three to six months, and membrane replacement every five to ten years. Annualized maintenance cost over a five year cycle would be approximately \$100 per year.

RO Advantages/Disadvantages. RO provides very broad spectrum removal of nearly all mineral contaminants. One disadvantage of RO treatment is that the water can become somewhat more corrosive with the removal of the water's alkalinity. Thus, new plumbing fit-tings on the faucet and line from the treatment unit must be copper and lead free, preferably plastic.

3. Anion Exchange

Anion exchange treatment is explained below under "whole house." Anion exchange modular cartridges are produced for small volume treatment, however, their relatively low capacity make them less likely to be chosen for point-of-use treatment.

4. Distillation

Distillation can also be used to produce a small amount of treated water. (Distillation is not widely used however, due to its high operational cost (i.e. kilowatts) and reject heat during summer months.) See fact sheet <http://www.des.nh.gov/factsheets/ws/ws-2-15.htm> for more information concerning distillation. Cost of distillation treatment, which is highly automated and directly connected to the plumbing, would be approximately \$2,000 installed and warranted by others. The cost of a countertop, pour through distiller, would be approximately \$1,000. Maintenance consists of cleaning residual minerals from the boiling chamber periodically. Annual operation and maintenance cost would be \$200-\$300 primarily for electricity.

Whole House Size Treatment Systems

A family of four in a single family home typically uses approximately 250 gallons of water per day for inside uses. As the amount of treated of water increases, the relative economics of some treatment methods may change.

1. Adsorptive Media

Adsorptive media is typically used for whole house treatment. Maintenance consists of replacing the media periodically, about every one to two years depending on the well's water quality. Adsorptive media whole house treatment for a typical family of four, with pre-oxidation by catalytic media, would cost approximately \$2,400. The loose adsorptive media may be disposed of with your household trash since the arsenic is bound to the media. Annual operation and maintenance would consist of media replacement. Annual operational costs for replacing the media would be approximately \$700-\$1,200 depending on media type and water quality. DES recommends that the annual maintenance cost be carefully considered as part of the purchase evaluation. A series configuration would increase the cost.

2. Anion Exchange.

Anion exchange is similar to conventional water softening except it removes the negative ion (arsenate) rather than the positive ions. Anion "softening" exchanges the contaminant ions for less objectionable ions. In this case, chloride is added to the treated water as the negatively-charged arsenic ions are removed. (See fact sheet <http://www.des.nh.gov/factsheets/ws/ws-2-12.htm> for an explanation of ion exchange treatment.) Anion exchange increases a water corrosiveness by removing alkalinity. This can be rectified by using a bicarbonate mineral as part of the salt regeneration solution.

The retail cost of anion exchange is approximately \$1,800. Annual operation and maintenance cost for salt would be approximately \$150 per year.

3. Reverse Osmosis

The cost an RO treatment system to produce 250 gallons of water per day would be approximately \$5,000-\$10,000. Annual maintenance cost would be approximately \$300 per year. RO equipment of this size is generally not cost effective for whole home treatment.

4. Iron Treatment Systems

Iron is a very common water quality constituent that causes rusty brown staining of water use fixtures and clothing. In cases where the **oxidation-filtration method** (birm, greensand) is being used to remove iron, arsenic will also be removed. The efficiency of arsenic removal in this option varies substantially with the water's iron quality and the precise type of treatment. Water quality tests are necessary to determine if there is significant arsenic removal for the particular iron oxidation/filtration treatment method used. Oxidation filtration, whole house treatment cost, assuming the presence of iron, costs approximately \$2,300. See fact sheet www.des.state.nh.us/factsheets/ws/ws-3-7.htm.

Drinking Rusty Water. If water quality tests have shown that the water has both an elevated concentration of arsenic and iron, any **rusty colored, untreated** water is likely to have **very high** arsenic levels, and should not be consumed.

Periodic Maintenance, Sampling Layout

The effectiveness of a treatment process should be determined by periodic sampling. Once the treatment process has been proven and the longevity determined, sampling frequency can be reduced. Some New Hampshire water conditioning firms suggest adding a second arsenic removal method, in a series configuration, to capture any arsenic that escapes the first device. For further information concerning the evaluation of equipment guarantee, the layout and installation of a water treatment system, and other purchase decisions, see the fact sheet <http://www.des.nh.gov/factsheets/ws/ws-2-5.htm>.

For More Information

For more information call the DES Water Supply Engineering Bureau at (603) 271-3139. We would appreciate your suggestions concerning this fact sheet. Drinking water fact sheets are available through the DES web site at: www.des.nh.gov/wseb then select: **fact sheets**. Please check the DES internet site annually for updates to this document. 4/06

Other Arsenic Reference Sites

US Environmental Protection Agency, www.epa.gov/safewater/arsenic/index.html

Agency for Toxic Substances and Disease Registry (ATSDR),
www.atsdr.cdc.gov/arsenic/index.html.

Dartmouth University, Toxic Metals Research Program,
www.dartmouth.edu/~toxmetal/TXQAas.shtml.